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Objektyp: **Article**

Zeitschrift: **Mitteilungen der Schweizerischen Entomologischen Gesellschaft = Bulletin de la Société Entomologique Suisse = Journal of the Swiss Entomological Society**

Band (Jahr): **79 (2006)**

Heft 1-2

PDF erstellt am: **13.09.2024**

Persistenter Link: <https://doi.org/10.5169/seals-402916>

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On the microdistribution of species of Drosophilidae and some other Diptera across a forest edge

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Arthropod biodiversity was measured at forest edges in north-western Switzerland, based on collections made by various traps. They were installed along transects, reaching horizontally from the open cultivated land up to 50 m into the forest and vertically, from the ground up to the tree tops.

Here we report on the microdistribution of Drosophilidae and some other dipteran families within the ecotone of a beechwood forest at Rickenbach SO. A majority of species showed their highest abundance at the forest edge, rather than in the forest interior. Typical forest species are mushroom feeder drosophilids like *Leucophenga maculata*, *Hirtodrosophila cameraria* and *Drosophila kuntzei*. Abundant presence in the canopy was observed particularly in *Periscelis annulata* and *Periscelis winnertzi*, but also in *Amiota alboguttata* and *Drosophila obscura*. Of particular interest is the second record of *Leucophenga hungarica* in Switzerland. The observed horizontal and vertical microdistribution patterns are discussed.

Keywords: Forest edge, canopy, microdistribution, Drosophilidae, Asilidae, Periscelididae.

INTRODUCTION

Most specimens of Diptera are collected by net sweeping on the ground, among undergrowth layers or on trees and bushes within the collector's reach. Also, automatic sampling methods like window traps (e.g. Schneider & Duelli 1997) or Malaise traps, usually placed on the ground, are operated. In addition, bottle traps (Allemand & Aberlenc 1991; Duelli *et al.* 2002) or special retainer traps (e.g. Toda, 1973; Schneider & Duelli 1997) have been used in the canopy of trees. These sampling methods are certainly less invasive than tree fogging (see e.g. Floren 2003; Srinivasa *et al.* 2004).

For Drosophilidae, the standard method of collecting is baiting by fermenting substances placed on the ground, but bottle traps or retainer traps have also been used in the canopy (e.g. Toda 1973; Bächli *et al.* 2004). A series of studies of the vertical microdistribution have been made in Hokkaido (Toda 1973, 1977, 1987; Beppu 1980; Tanabe *et al.* 2001) and in central Japan (Beppu 1984, 1986, 1988). In addition, the horizontal microdistribution has been studied as well (Toda 1974; Beppu 1976, 1978; Kimura 1976).

In 1994/1995, a series of collections have been made at four localities in Switzerland using a combination of horizontal and vertical transects through five forest

edges (Flückiger & Duelli 1997, Flückiger *et al.* 2003). For certain insect groups collected in these surveys, the results have been published (Flückiger & Peter 1998; Flückiger 1999; Duelli *et al.* 2002; Wermelinger *et al.*, in prep.). Among the Diptera, only detailed results for hoverflies (Syrphidae) were included (Flückiger 1999), whereas other Diptera have not been further analyzed.

The aim of this publication is to show, based on the microdistribution of some Diptera, particularly Drosophilidae in a forest ecotone, that a majority of forest species are in fact forest edge species.

MATERIAL AND METHODS

At a south/southeast oriented forest edge in Rickenbach (7°51'E, 47°21'N, ca. 600 m a.s.l.), about 4 km west of Olten, Canton Solothurn, a combination of a horizontal and a vertical transect was set: a horizontal one from the open, cultivated area (Mesobrometum) across the forest edge, ending 50 m inside a managed forest (7 trapping stations), and a vertical one at the forest edge, starting from the ground and reaching a maximum height of 28 m (8 trapping stations). Where transects were crossing one position was common for both transects. At each position, a combination of a Malaise trap (Schneider and Duelli 1997), a yellow pan trap and a window trap was used. The traps were emptied weekly from March to November in both years 1994 and 1995. For the Diptera analysis presented here, all weekly samples of the year 1995 were pooled for every trap station. Details for the traps and of the samplings are given by Flückiger (1999). The flies were originally stored in 70 % ethanol. For the determination, almost all specimens were dried and pinned.

RESULTS

General overview

In total, 298 specimens of Drosophilidae, Asilidae and Periscelididae were collected (Tab. 1). In addition, the following species were recorded: one specimen of *Acartophthalmus nigrinus* (Zetterstedt, 1848) (at height 16 m), 11 specimens of a Lonchaeidae species (at forest edge up to 20 m height), 9 specimens of a Scatopsidae species (at height 16 m) and 1 specimen of an *Odinia* species (Odiniidae) on the ground in the interior of the forest.

The three Asilidae species are common in Switzerland. Most asilid species are hunters sitting on exposed branches, watching for a passing prey. We would expect therefore, that they were found mainly along the forest edge. This is generally true for the two *Choerades* species, but not for *Tolmerus atricapillus*, of which the vast majority was found in the cultivated land area.

Horizontal microdistribution

Most of the drosophilids are typical woodland species, a fact also shown by our material; typical mushroom feeders were recorded in the forest, usually close to the ground. The following species, however, were found in the grassland as well: *Stegana furta*, *Scaptomyza pallida* (Fig. 1), *Drosophila subobscura* (Fig. 1), *D. obscura*, and in larger numbers, *D. helvetica* (Fig. 2). For most species, the number of

Tab. 1. Total number of flies collected in the species of Drosophilidae, Asilidae and Periscelididae.

Taxon	specimens
Drosophilidae	
<i>Amiota alboguttata</i> (Wahlberg, 1839)	6
<i>Amiota basdeni</i> d'Assis Fonseca, 1965	23
<i>Amiota flavopruinosa</i> Duda, 1934	2
<i>Chymomyza amoena</i> (Loew, 1862)	1
<i>Drosophila helvetica</i> Burla, 1948	39
<i>Drosophila kuntzei</i> Duda, 1924	4
<i>Drosophila obscura</i> Fallén, 1823	11
<i>Drosophila phalerata</i> Meigen, 1830	1
<i>Drosophila subobscura</i> Collin, 1936	22
<i>Hirtodrosophila cameraria</i> (Haliday, 1833)	2
<i>Leucophenga hungarica</i> Papp, 2000	1
<i>Leucophenga maculata</i> (Dufour, 1839)	6
<i>Phortica semivirgo</i> (Máca, 1977)	1
<i>Scaptomyza graminum</i> (Fallén, 1823)	11
<i>Scaptomyza pallida</i> (Zetterstedt, 1847)	31
<i>Stegana furta</i> (Linnaeus, 1767)	4
<i>Stegana similis</i> Laštovka et Máca, 1982	8
Asilidae	
<i>Choerades fimbriata</i> (Meigen, 1820)	2
<i>Choerades marginata</i> (Linnaeus, 1758)	20
<i>Tolmerus atricapillus</i> (Fallén, 1814)	20
Periscelididae	
<i>Periscelis annulata</i> (Fallén, 1913)	76
<i>Periscelis winnertzi</i> Egger, 1862	7

specimens shows a clear peak at the forest edge, whereas far within the forest distinctly fewer flies were observed (e.g. in *Drosophila subobscura*, Fig. 1).

Vertical microdistribution

Mainly because of ecological considerations, standard collections of Drosophilidae are made on the ground, but one would expect that at least some species, known to be vagile, could enter the canopy as well.

Abundant species like *Drosophila subobscura* (Fig. 1), *Scaptomyza pallida* (Fig. 1) and *Periscelis annulata* (Fig. 3), were encountered in almost all height steps, but even less abundant species were sporadically found up to the highest canopy (e.g. *Amiota alboguttata* (Fig. 2), or *Drosophila obscura*). In general, the vertical distribution patterns of several species are much alike, e.g. *Amiota basdeni* (Fig. 3) or *Scaptomyza graminum* (Fig. 4), but their maximum height encountered is 20 m.

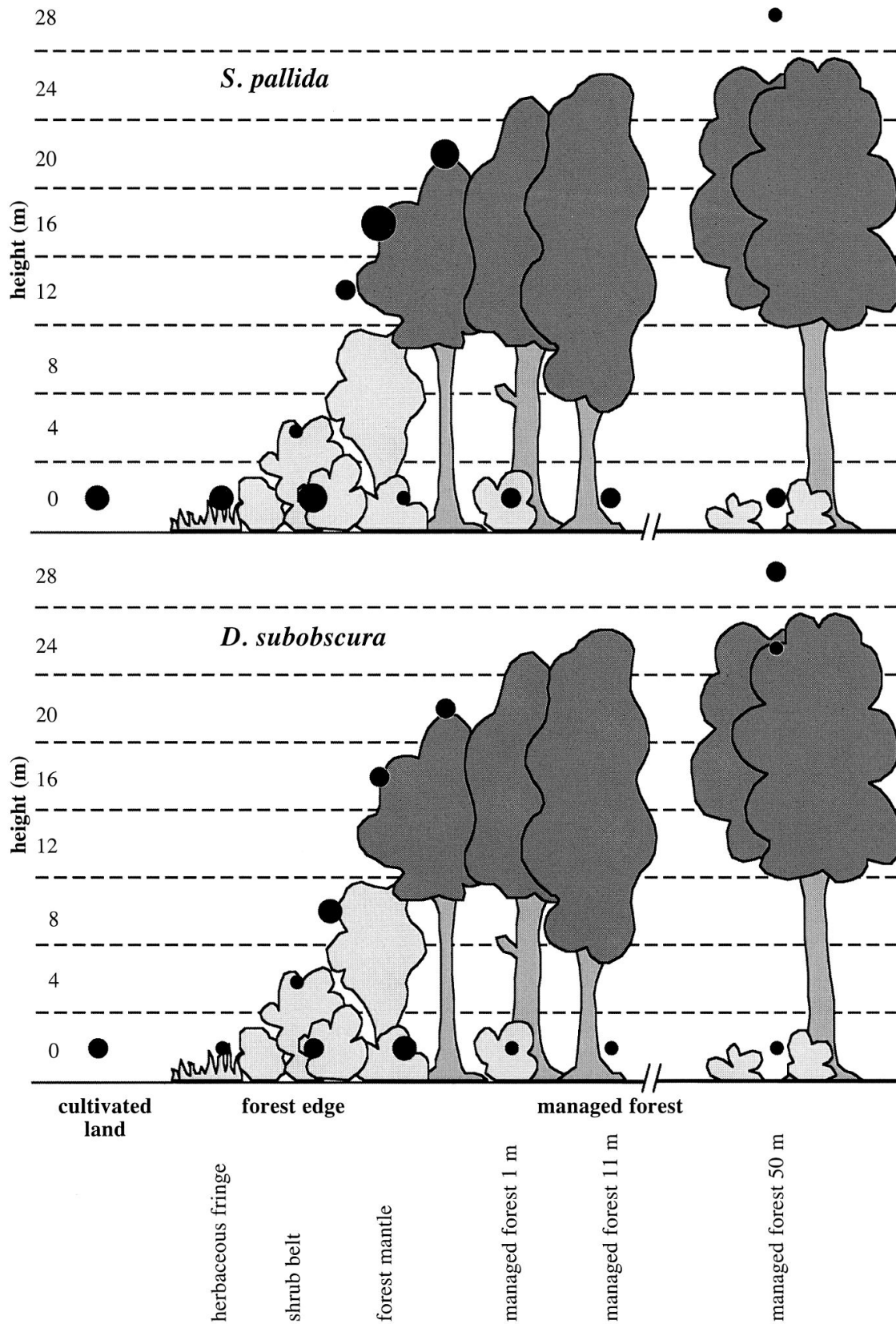


Fig. 1. Schematic representation of the forest edge situation of the study site, showing the distribution pattern (black circles) of *Scaptomyza pallida* (above) and *Drosophila subobscura* (below). The circle area represents the number of specimens collected.

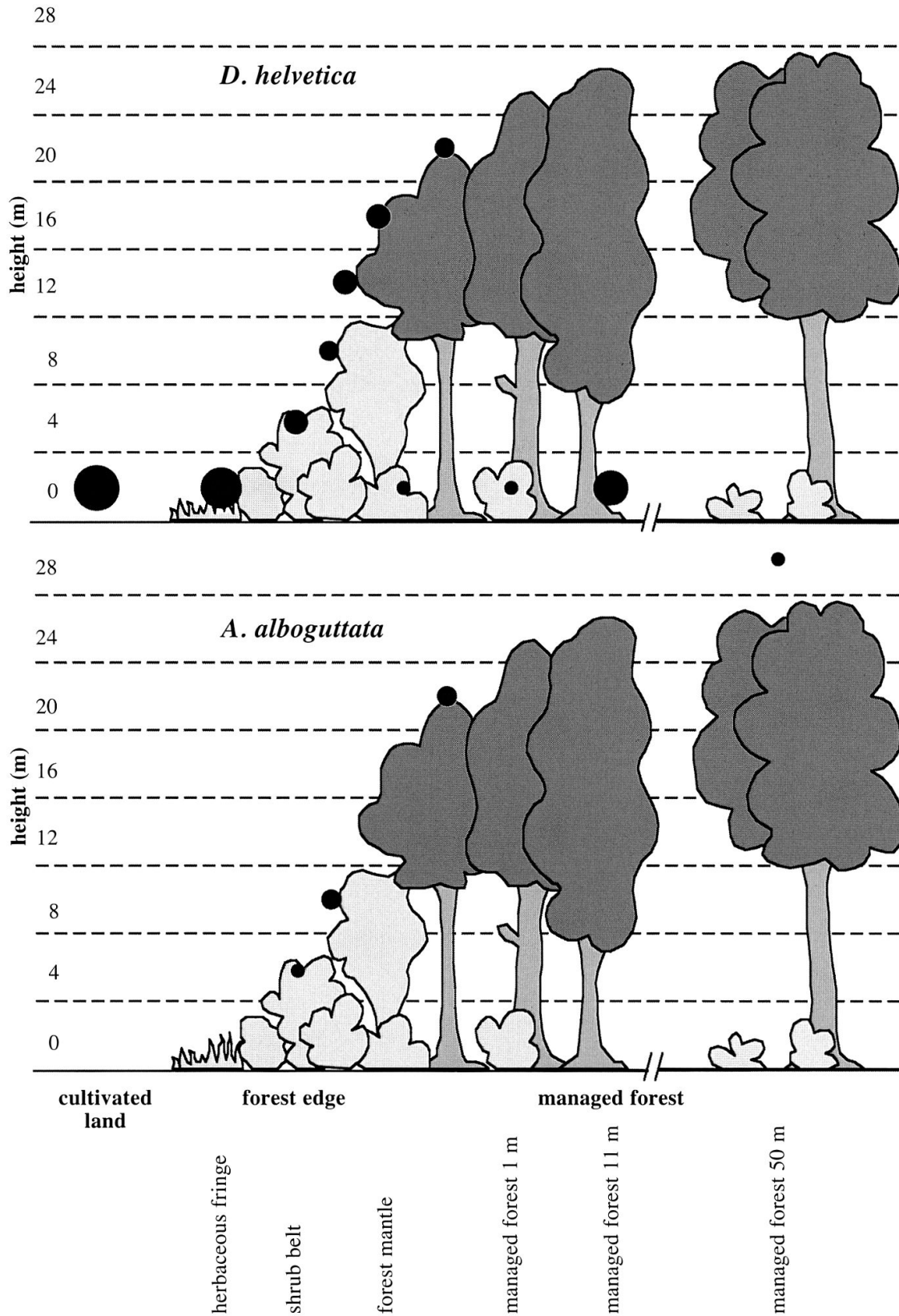


Fig. 2. Schematic representation of the forest edge situation of the study site, showing the distribution pattern (black circles) of *Drosophila helvetica* (above) and *Amiota alboguttata* (below). The circle area represents the number of specimens collected.

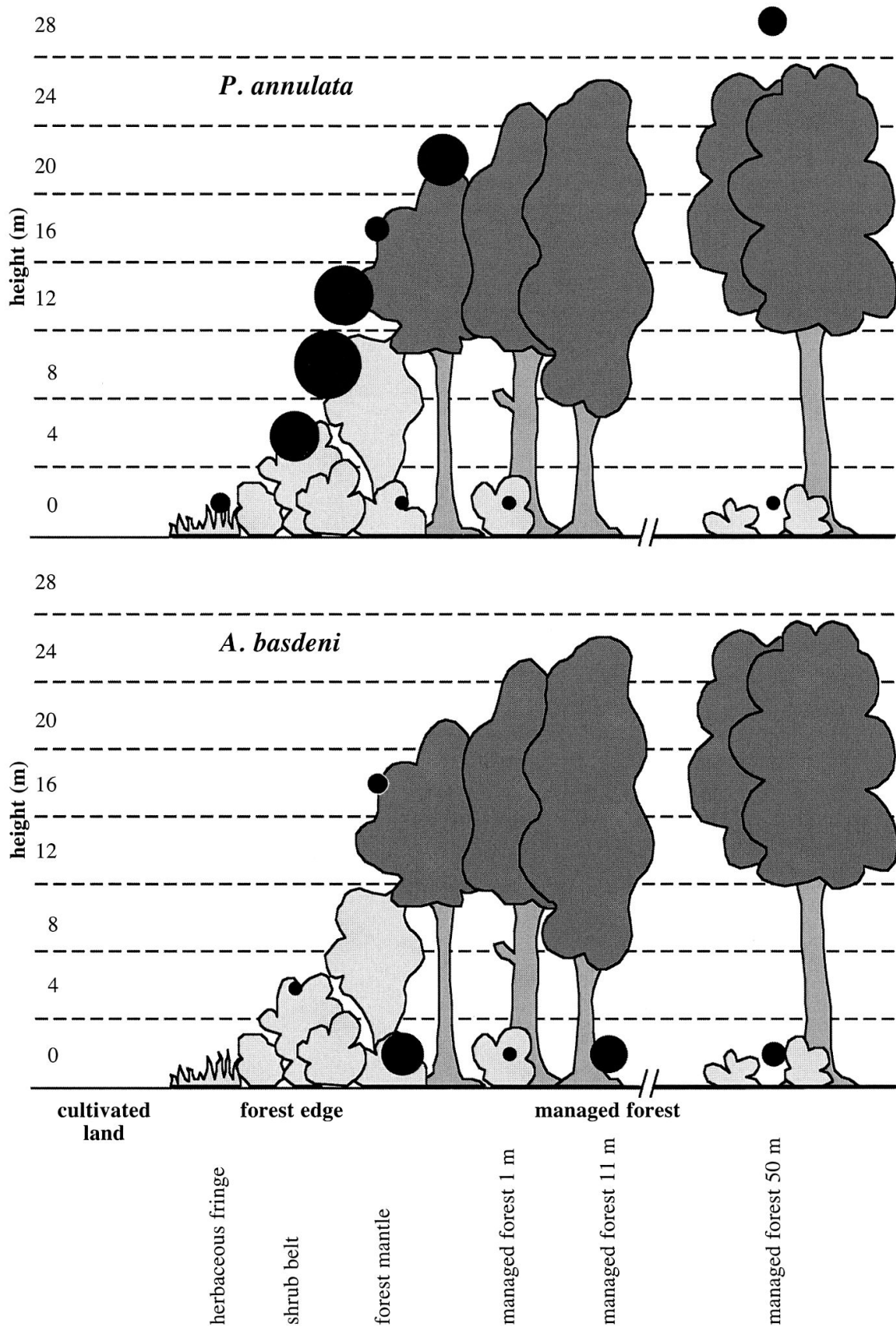


Fig. 3. Schematic representation of the forest edge situation of the study site, showing the distribution pattern (black circles) of *Periscelis annulata* (above) and *Amiota basdeni* (below). The circle area represents the number of specimens collected.

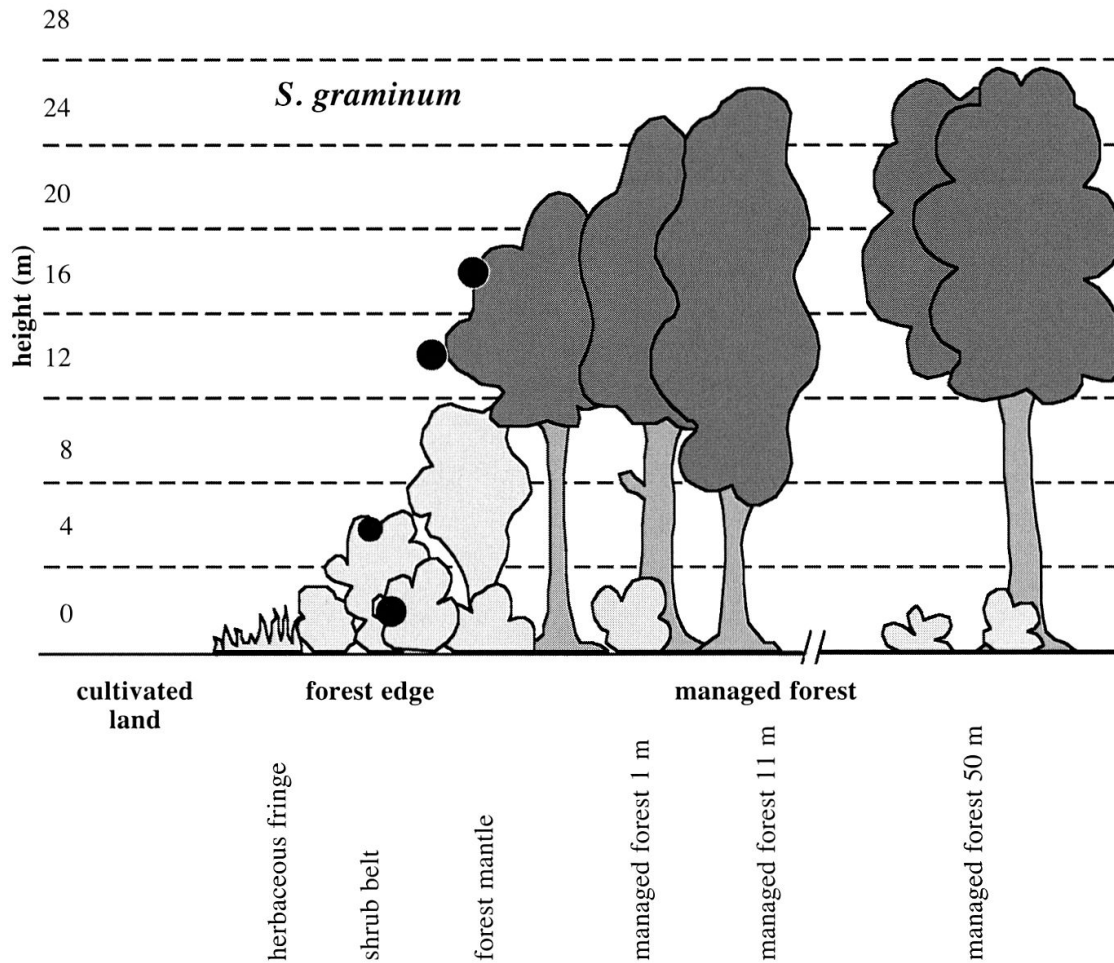


Fig. 4. Schematic representation of the forest edge situation of the study site, showing the distribution pattern (black circles) of *Scaptomyza graminum*. The circle area represents the number of specimens collected.

Periscelis annulata is found in large numbers in almost all vertical steps, particularly along the forest edge (Fig. 3). The same might apply for *P. winnertzi*, of which, however, a lower number of specimens were collected.

DISCUSSION

Among the Drosophilidae, the most interesting species is *Leucophenga hungarica* Papp, 2000; this is the second record in Switzerland, in addition to a few specimens collected near Zürich (Merz *et al.* 2001; Bächli *et al.* 2002). This species has been recorded in low numbers in Hungary, the Czech Republic, Slovakia and Switzerland (Bächli *et al.* 2004). No details of its biology are known, however, it may be a fungal breeder species, a typical biological background for Palearctic *Leucophenga* species. The majority of drosophilid species mentioned in Tab. 1 is traditionally attracted by fermenting baits, but usually in quite different abundance (e.g. Burla & Bächli 1991; Band *et al.* 1998). In particular, the *Amiota* species are rarely attracted by baits but may be abundant in bottle traps (Bächli *et al.* 2004).

Also, *Stegana* species, not really attracted by baits, are common in collections made by net sweeping above the ground.

The species of Periscelididae are generally considered to be rare. However, they have been collected in large numbers in the (lower) canopy (Bächli 1997b). Thus, it is not surprising that about one fourth of all Diptera collected at Rickenbach, particularly from the vertical transect, belongs to this family. Our results show that both *Periscelis annulata* and *P. winnertzi* are distributed up to the highest parts of the canopy. On the other hand, some specimens of *P. annulata* were found at ground level as well (Fig. 1). Larvae of *Periscelis* species have been recorded in sap flux of wounded trees (Stubbs & Chandler 1978; Ferrar 1987); as such wounds may occur in the canopy as well, we can expect that the microdistribution covers all height steps.

Greuter (1963) has shown that *Drosophila subobscura* is moving daily from forests to the adjoining open areas. That may explain why some specimens were found on cultivated land (Fig. 1). There is, on the other hand, no explanation for the large number of *D. helvetica* found outside of the forest (Fig. 1), because the distribution pattern of this species has not been studied before. In many collections made during the last 20 years, *D. helvetica* is outnumbering *D. subobscura* and becoming the dominant species (Bächli, unpubl.).

Scaptomyza pallida (Fig. 1), a general scavenger, is known to occur almost everywhere in the grassland (Bächli *et al.* 2004). The same may apply for *S. graminum* (Fig. 4), a species with mining larvae living in various plant species of the herbaceous layer (Máca 1972). That both species have been found in the canopy is rather surprising.

The *Amiota* species are rarely attracted by fermenting baits placed on the ground but have been collected by net sweeping in the herbaceous layer and by wine/beer bottle traps in the canopy (Bächli *et al.* 2004), placed at a height of 4-5 m. The typical distribution pattern is shown by Fig. 1 for *A. alboguttata*; the pattern found for *A. basdeni* is different, because the majority of specimens has been found on the ground; this corroborates the findings that this species is not rare in many samples caught without baiting (Bächli & Merz 2005). *A. flavopruinosa* is also a rare species; it is probably widespread in Europe and also collected by wine/beer traps (Bächli, 1997a).

Extensive studies of the vertical microdistribution of drosophilids have been made in Japan (Toda 1973, 1977, 1987; Beppu 1980, 1984, 1986, 1988). In all collections, these authors have used retainer traps filled with fermenting bait which gave quite different results compared to the Rickenbach samples from «neutral» flight traps. The traps were set at a maximum height of 23 m (Toda 1987), but usually at less than 15 m. Considering the presence of species particularly attracted by baits in the Japanese samples, we can see that the canopy samples were mainly represented by a number of *Amiota* species, particularly in the traps at higher steps. This is in good correlation with other results (Bächli *et al.* 2004; Bächli, unpublished).

The Diptera samples, in particular the distribution of species of Drosophilidae in the horizontal and vertical transects corroborate the importance of forest edges as biodiversity hotspots in Drosophilidae (Burla, 1951; Burla & Bächli 1991) as well as their significance as biodiversity hotspots in general (Flückiger & Duelli 1997; Duelli *et al.* 2002).

ACKNOWLEDGMENTS

We thank Peter Wirz and Karin Schneider for field work, Ruth Bärffuss and Karin Schneider for the separation of the collected material, and the Swiss National Science Foundation for financial support. Bernhard Merz and Jan Mácá have given useful comments on a draft of the manuscript.

ZUSAMMENFASSUNG

Im Rahmen eines Forschungsprojektes über den Beitrag von Waldstrukturen zur regionalen Biodiversität wurden an einem Waldrand am südlichen Jurafluss des Kantons Solothurn Untersuchungen zur Diversität von Arthropoden gemacht. Auf einem horizontalen Transekt, vom Kulturland bis 50 m innerhalb des Waldes, und einem vertikalen Transekt wurde eine Kombination von Fallen eingesetzt. Wir berichten hier über die Feinverteilung von Drosophiliden und anderer Dipteren an einem Waldrand in Rickenbach SO. Bei der Mehrzahl der Arten wurde die grösste Abundanz im Bereich des Waldrandes festgestellt, während im Waldinnern vor allem typische Pilzbewohner, z.B. *Leucophenga maculata*, *Hirtodrosophila cameraria* und *Drosophila kuntzei* gefunden wurden. In den Baumwipfeln waren vor allem *Periscelis annulata* und *Periscelis winnertzi* anzutreffen, aber auch *Amiota alboguttata* und *Drosophila obscura*. Von besonderem Interesse ist der Zweitfund von *Leucophenga hungarica* in der Schweiz. Die horizontale und vertikale Feinverteilung wird diskutiert.

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(received April 21, 2006; accepted May 17, 2006)